ON COLLECTIONS TO ILLUSTRATE THE EVOLUTION AND GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

By George H. Carpenter, B.Sc.,
Assistant Naturalist, Science and Art Museum, Dublin.

THE educational function of museums has been much discussed in recent years, and especially at the previous meetings of this Association. Some account of the efforts which we have made in Dublin to teach, by means of our collections, the leading facts of Animal Distribution and the main factors in Animal Evolution may therefore be of interest to the present meeting.

By the transfer of the palæontological collections to a separate room, the whole of the wall-cases on one side and half the floor space of the ground floor of our main natural history building was, about three years ago, rendered available for the exhibition of a collection to illustrate the Geographical Distribution of Animals. With the arrangement of this collection I had the honour to be entrusted. We believe it to be the first attempt of the kind made in the Kingdom.

It is obvious that, in forming such a collection, the systematic zoological series could not be robbed of characteristic specimens. In the case of many common species, however, the geographical exhibition afforded a welcome use for duplicates. In other cases, where we had no duplicates of a species, but examples of several species of a genus, one species was appropriated for the geographical, leaving the rest for the zoological series. Moreover, the ground floor of the museum had long been

the home of skeletons and stuffed skins of various mammals (elephant, rhinoceros, hippopotamus, etc.), too large to be accommodated in he zoological collection upstairs. These were now arranged with regard to their habitat.

The series in the wall-cases runs from left to right, commencing at the entrance door. The first two cases are devoted to some general teaching on distribution. "Animals with a Wide Distribution" are represented, as far as possible, by widely ranging species of cosmopolitan genera—*e.g.*, *Canis lupus*, *Falco peregrinus*, *Anas boschas*, *Vanessa cardui*. The range of both genus and species is shown on maps of the world, while printed labels point out that these are dominant types on account of their ready adaptability to the most distinct surroundings. "Animals with a Confined Distribution" are shown to be either survivals of archaic types, as the Australian kangaroos and the Mascarene lemurs, or special developments within a restricted area, as the Neotropical rodents, toucans, and Heliconid butterflies. The Dipnoid fish *Protopterus* serves to illustrate "Animals with a Discontinuous Distribution," on account of approaching extinction. The "Distribution of Animals in Past Times" is brought home to the visitor by British specimens of *Ichthyosaurus* vertebræ and mammoth molars, while a sketch-section across England and Wales explains the geological terms used in describing the age of these remains. (The almost complete series of rocks in England makes that country preferable to Ireland for this purpose; and Holyhead, where the section begins, is familiar to most Dublin folk.) "The Great Ice Age" and its effect on modern distribution is explained by label and map, and illustrated by a local scratched stone. "How Distribution teaches the History of Animal Groups" is shown by an opossum, with map showing the modern

home of the group in South America, and the regions where Tertiary opossums lived in Europe and North America. Lastly, a map divided into "The Six Great Regions" of Sclater and Wallace is shown, each region being distinguished by a special colour, which is used for its characteristic groups throughout the rest of the collection. The descriptive labels for these introductory cases will be found on pp. 114—116.

Although the well-known Six Regions of Sclater are, on account of their sub-equal size and evident geographical boundaries, most convenient for the study of animal distribution, I am inclined to consider the union of the northern Nearctic Region with the Palæarctic, and the establishment of a Sonoran Region for central and southern North America (as recently suggested by Merriam and others) more natural. It has, indeed, been suggested that our collection should be partly rearranged upon these lines.

In the part of the collection illustrating the fauna of the Regions, the wall-cases are, as a rule, appropriated to mammals, while high table-cases contain the birds, reptiles, etc. Considerations of space, however, forbade such a division to be strictly followed: the Australian struthious birds, for instance, had to be put with the mammals in the wall-case, while, the Ethiopian wall-case being overcrowded, the monkeys and lemurs of that Region have been lately accommodated in special table-cases. The arrangement in each Region could only be roughly systematic, but, as far as possible, related forms have been kept together. For example, a convenient small wall-case in the part of the room allotted to the Australian Region has enabled us to collect together the Placental mammals of that part of the world, and thus emphasise their extreme paucity when compared with the marsupials.

Shallow desk-cases beneath the windows between the

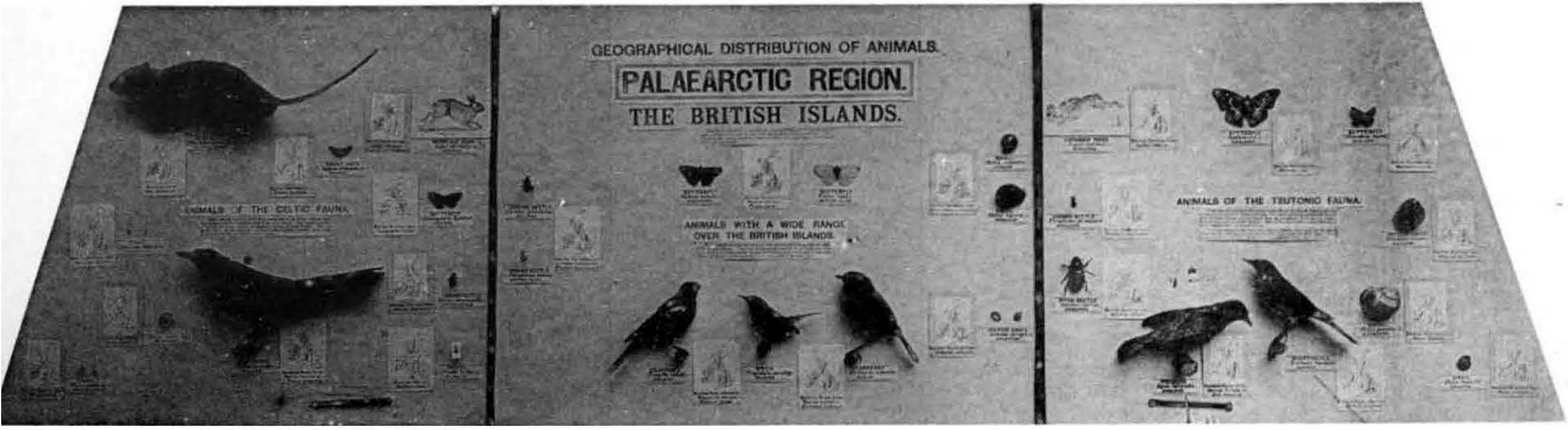

GEOGRAPHICAL DISTRIBUTION OF ANIMALS.
PALAEARCTIC REGION.
THE BRITISH ISLANDS.
ANIMALS WITH A WIDE RANGE OVER THE BRITISH ISLANDS.
ANIMALS OF THE TEUTONIC FAUNA.

Plate 8.

wall-cases have been made use of for exhibiting some characteristic invertebrates. But the first of these in the Palæarctic Region has been specially set apart to show some facts of distribution within our own islands. We here contrast the "Animals with a Wide Distribution" (chaffinch, redbreast, white butterflies, etc.), on the one hand with the "Animals of the Celtic Fauna" (as *Lepus variabilis*, *Turdus torquatus*, *Canonympha typhon*, *Helix pisana*) confined to northern, western, and alpine districts, and specially characteristic of Ireland, and on the other with the "Animals of the Teutonic Fauna" (as *Erithacus luscinia*, *Lucanus cervus*, *Paludina vivipara*), which are almost confined to the east and south-east of England.

In choosing specimens to illustrate the fauna of the Regions, we have, for the most part, selected species of peculiar genera. Characteristic genera, even if not peculiar, have, however, been also included (*e.g.*, the hyæna in the Ethiopian or the tapir in the Neotropical Region). More rarely, characteristic species of widely ranging genera are shown (*e.g.*, the tiger in the Oriental and the black bear in the Nearctic Region). Every specimen is accompanied by a map of the world, on which the range of the species, genus, or family (whichever is peculiar) is shown by the distinctive colour of the Region, while an explanatory label points out the bearing of the facts indicated. In some cases the map has been used to show the range of related forms in other Regions. For example, a Camel skeleton stands in the Palæarctic section of the room, and the appended map shows not only the range of the Camel but that of the Neotropical Camelidæ as well. In such a case as this, the ranges of the characteristic groups in both Regions are shown by the two distinctive regional colours on the map. But when a group highly characteristic of one Region ranges into one or two neighbouring ones, the

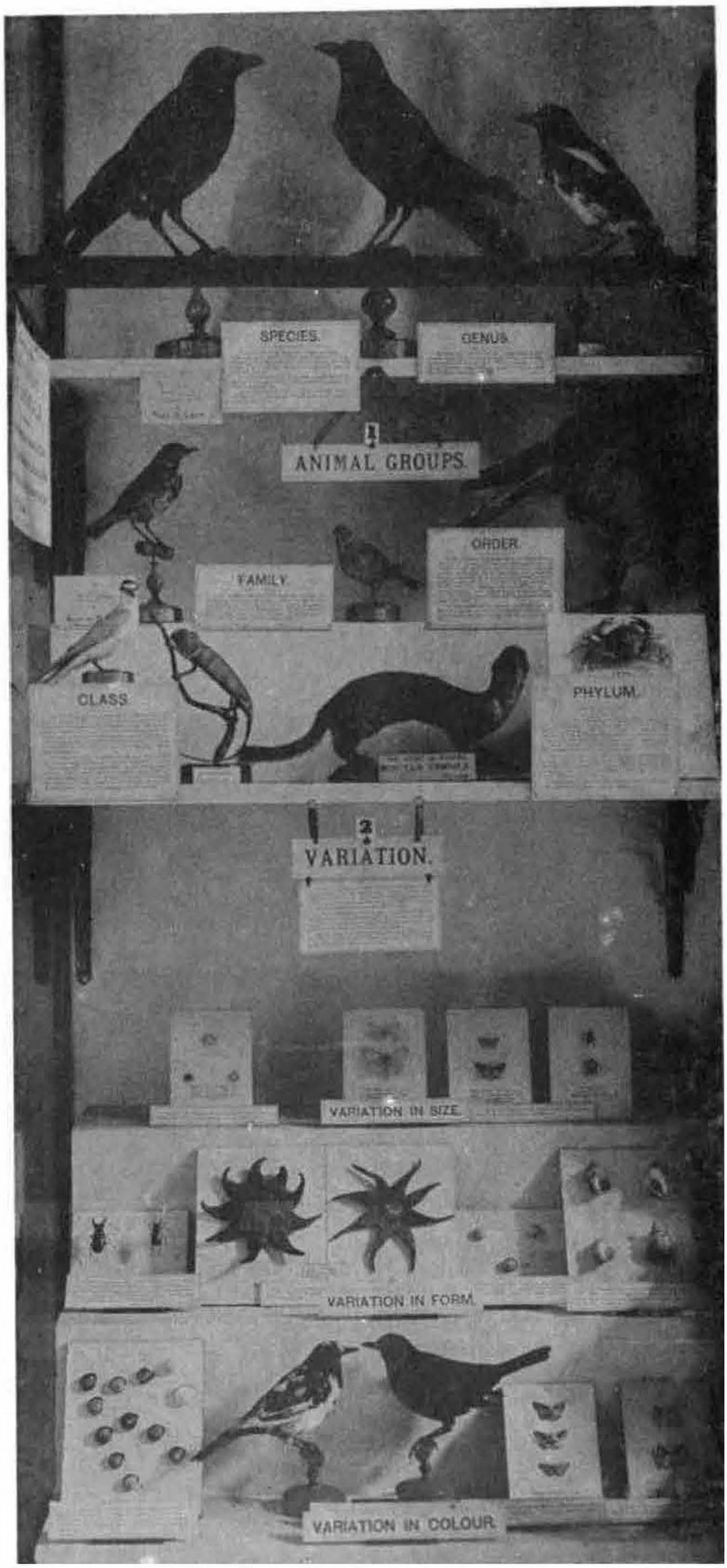
colour of the "headquarters" only is used. For instance, a chameleon is exhibited in the Ethiopian case, and the range of a few species of the family is shown on the map to extend into the Palæarctic and Oriental regions by means of a light wash of the characteristic Ethiopian colour (blue), which by its deep tint over the Ethiopian districts indicates a multitude of species there.

The distribution of extinct forms has been shown by a special colour in the case of groups where it has an evident bearing upon the range of living animals. The tapirs, horses, and elephants are examples of this.

A selection of descriptive labels from the Regional cases will be found on pp. 117—125.

It should perhaps be mentioned that, in addition to this special geographical collection, maps showing the range of families or genera are being also placed with the specimens in the systematic series. Almost every person has now some knowledge of geography, and the sight of a familiar object, like a map of the world, attracts many intelligent visitors to the further study of the surrounding specimens.

When the geographical collection had been completed, a single wall case at one end of the room was still unoccupied. It was resolved to set this apart for the illustration of the facts—so familiar now to all naturalists, but still so strange to many otherwise well-informed persons—on which the doctrine of descent rests. Our label calls this a collection to illustrate the "HISTORY OF ANIMALS." The case is 18 feet long, 7 feet high, and 3 feet deep, divided by doors into five vertical "columns," each of which is divided by a deep shelf into an upper and lower portion. Above this shelf, and also above the floor, are shallower shelves arranged like steps. Consequently, if we regard our case as a book to be read in the usual way, from left



Collection to Illustrate

THE HISTORY OF ANIMALS.

This Collection is meant to Illustrate those facts of Animal Life and Structure which teach us

to right, we have five "columns," each divided into two "chapters," while each chapter consists of three "lines" of specimens. A photograph of the case has been reproduced, and a set of the descriptive labels reprinted (pp. 126—142).

The first chapter is headed ANIMAL GROUPS, and shows the increase of difference between living forms. It serves also as a lesson in zoological terms. Examples of two species of a genus, two genera of a family, two families of an order, two orders of a class, two classes of a phylum, and lastly two separate phyla, are exhibited side by side. Printed labels point out the increasing nature of the differences, and suggest that this fact is best explained by increased distance of relationship.

The lower division of the first column illustrates VARIATION. Examples are given of Variation in Size, Form, and Colour, in species of different groups; and the labels suggest that the extremes of such variable forms would be reckoned as distinct species were the intermediate varieties to die out. Variation is thus set forth as the first great factor in the origin of new species.

The upper section of the second column deals with the STRUGGLE FOR EXISTENCE. A female fish with ovary exposed, and a blow-fly with eggs, serve as texts for the Rate of Increase in Numbers. Ways of gaining Livelihood are illustrated by vegetable-feeders (squirrel and cockchafer), flesh-eaters (spider and sparrow-hawk), each with an appropriate prey; and a parasite (*Sacculina*), the degeneration resulting from the last habit being specially pointed out.

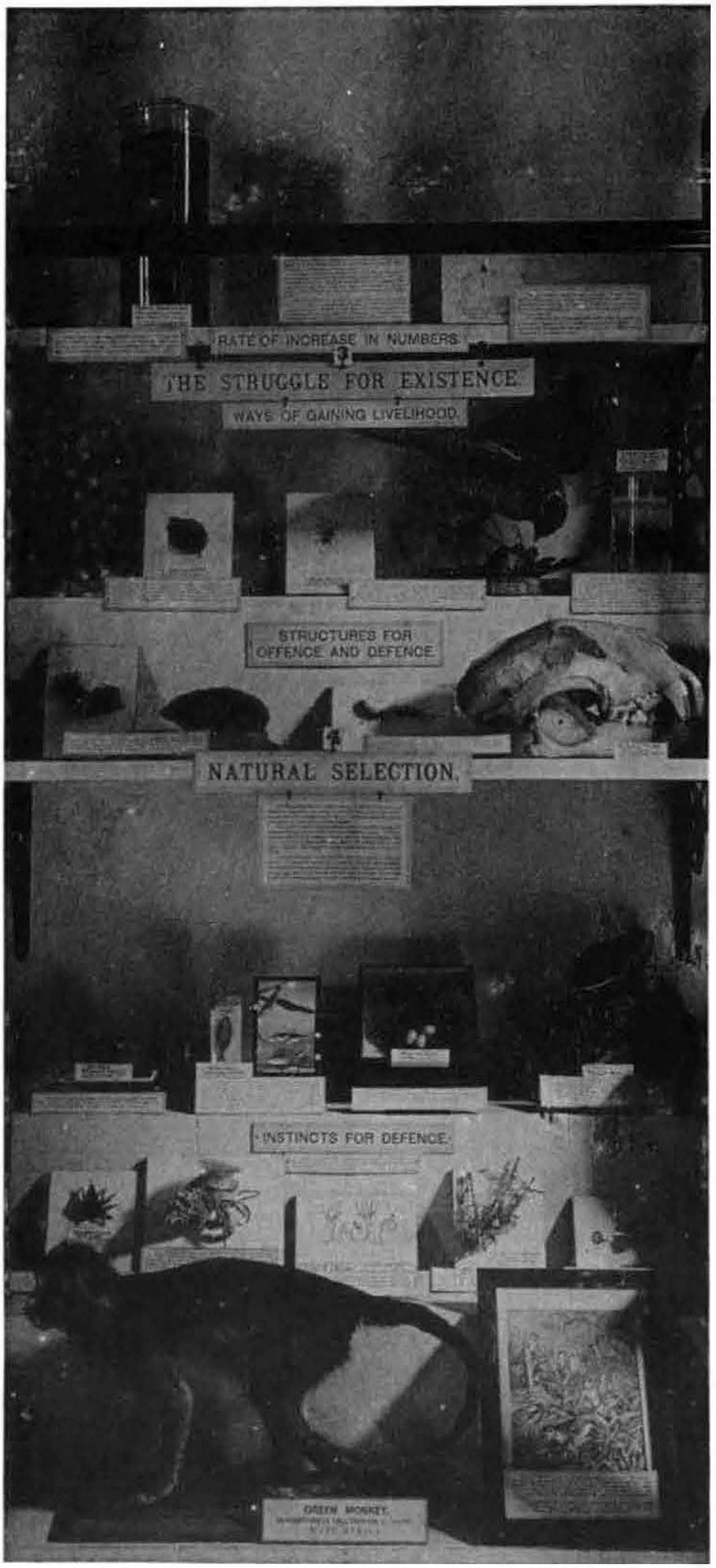
Thus the student is led to the principle of NATURAL SELECTION, which is explained, as far as is possible in a short label, and illustrated by Structures for Defence and Offence—the shell of a snail, the spines of a hedgehog, the

canine teeth of a tiger, which are of obvious use to their possessors in the struggle for life. Instincts for Defence are next dealt with, the labels pointing out that, for the preservation of races, mental and moral qualities and care for young are of greater value than mere force. A spider-crab with seaweed-covered limbs, and a hermit-crab with sea-anemone, show instincts for self-defence. The nests of the stickleback, trap-door spider, bullfinch, and weaver-bird illustrate skill in the construction of shelters for parent and young; while the growth of the social instinct is shown by a hydroid colony, bee community and troop of monkeys (the last illustrated by a stuffed specimen, accompanied by a picture of the troop).

In the third column the subject of Natural Selection is continued, the well-worn subjects of Protective Coloration, Warning Coloration, and Mimicry being illustrated by the mammals, birds, snakes, and insects which we all know so well. Perhaps because this particular branch of the subject has been so widely popularised, it is this section of our case which seems most strongly to attract attention.

The upper part of the fourth column illustrates Morphology, or, as the label calls it, SIMILAR PARTS IN DIFFERENT ANIMALS. The examples selected are an ophiurid, asteroid, and echinoid, to show the varying extent of the radial and inter-radial areas in the echinodermal exo-skeleton; and the fore-limbs of a lizard, monkey, bat, archæopteryx (drawing only), duck, sloth, deer, and ass, to show the modification of the vertebrate limb for various functions. In this exhibit corresponding parts are marked with distinctive colours.

The lower part of the column shows the LIFE-HISTORY OF INDIVIDUALS. Eggs of a bird and moth, magnified sketches of ova of cat and starfish, and of a protozoon,



Collection to Illustrate

THE HISTORY OF ANIMALS.

This Collection is meant to Illustrate those facts of Animal Life and Structure which teach us the History of Races.

are exhibited side by side. These are followed by magnified sketches of the gastrula stage in *Sagitta* and the frog, side by side with specimen, glass model, and magnified sketch of a hydroid. A fish, a tortoise, a bird, and a rat are next shown, with sketches of the young embryo of each, the similarity between the latter being pointed out in the label. This chapter is concluded with the metamorphosis of the tadpole into the frog, the caterpillar into the moth, and the nauplius larva into *Penæus* on one hand and a cirripede on the other.

In the upper part of the fifth and last column some evidence from Palæontology is set forth under the title of LIFE-HISTORY OF RACES. Palæozoic and living species of *Lingula*, and Mesozoic and recent species of *Ostræa* illustrate Descent without Modification. Progress from species to species is shown by the Paludinæ from Slavonian Tertiaries as expounded by Neumayr, while transition from genus to genus is illustrated by the Palæozoic cephalopods leading up to the ammonites. The familiar pedigree of the horse could not be omitted, though, owing to the small size of the case, it can only be shown by reduced sketches. The change from primitive to higher orders of fish is then traced out, special reference being made to the form of the tail, a point easily understood. Magnified sketches of the development of a living teleostean fish are given, to show that the same series of changes are gone through in the individual development.

SEXUAL DIFFERENCES are shown in the lower part of the fifth column. Relative size of the sexes is dealt with—spider and moth illustrating the female as larger, lion and stag (pictures only of course) the male. These mammals are also used as examples of the possession of combative organs in the male wanting in the other sex.

Tendency to passivity in the female is illustrated by insects in which that sex is wingless. The rest of the space is devoted to illustrate the tendency of the male to be ornamental and the female plain; the labels mention both the theories which are current on this subject.

SPECIMENS OF DESCRIPTIVE LABELS.

(*Each paragraph represents a separate label. The accompanying specimen will, in most instances, be obvious.*)

COLLECTION TO ILLUSTRATE THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

Animals with a Wide Distribution.

THE Wolf (*Canis lupus*) is a good example of a *species* with a very wide range; as it is found in Europe, North and Central Asia, India, and North America. The Wolf is classed with Jackals, Dogs and Foxes in the genus *Canis*. The only parts of the world without these animals in a wild state are Madagascar, the West Indies, New Zealand, and the Oceanic Islands. Hence the genus *Canis* has a distribution over nearly the whole world. Such wide distribution is a proof that these animals form a very dominant group, being able to establish themselves in all parts of the globe, and to adapt themselves to very varied climates and conditions of life.

The great Order of Perching Birds (*Passeres*) is one of the most widely spread groups of living animals. The Thrush Family (*Turdidæ*), which is reckoned the highest of the order, occurs in all parts of the world except New Zealand, and the true Thrushes (*Turdus*) form a genus which has a distribution as wide as that of the family to which it belongs.

Nearly all the families of the Birds of Prey (*Accipitres*) are world-wide in their distribution—for example the *Falconidæ*,

including the Eagles, Hawks, Kites, and Falcons. The true Falcons (*Falco*) are found everywhere but on the Pacific Islands. The very perfect correspondence of the structure of these Birds with their habits, and the presence in all parts of the world of smaller Birds, Mammals, and Fishes on which they can feed, explain their very wide range.

The Nymphalid Butterflies are a very widely spread group. The genus *Vanessa*, to which most of the highly coloured British Butterflies belong, ranges over the whole world. The species known as the "Painted Lady" (*V. cardui*) hus been found in almost all parts of the globe.

Animals with a Confined Distribution.

The true Lemurs are only to be found in the island of Madagascar. The Kangaroos and all other families of Marsupials (except one) are confined to Australia and the neighbouring islands. These animals are the survivors of very ancient groups which have been exterminated on the great continents by the competition of newer forms, but have been protected from such competition in the isolated districts where they are now found.

The Agoutis and many other Rodents are confined to Tropical and South America. Very many families of Birds and some of Insects are only to be found in the same districts. These creatures are not the survivors of ancient groups which have been exterminated elsewhere, but they have been developed and specialised within the region where they are now found, and, so far as we know, have never occurred anywhere else.

Animals with a Discontinuous Distribution.

The Dipnoid Fishes furnish an excellent example of discontinuous distribution. They occur in the rivers of Australia, Africa, and South America. Hence the countries in which they are found are separated from each other by great oceans, and as these Fishes are freshwater forms we know that they cannot have got from one continent to the other by sea. We know from fossil evidence that they inhabited the northern continents in Triassic times, and hence we infer that they were once spread over the earth's surface, but have now become extinct, except in those widely-separated districts in which they have still managed to survive. When a group of animals is found to be

scattered over the earth's surface in this way, it is usually safe to conclude that it is a very ancient race on the way to total extinction.

Distribution of Animals in Past Times.

In order to understand properly the distribution of living animals over the earth's surface, it is necessary to have some knowledge of the extinct animals whose remains are preserved in the rocks. For we regard the world-population of the present day as the modified descendants of these extinct races.

Teeth and bones of ancient Elephants have been found in many places in England and a few in Ireland. Thus we know that, at the time when the clay was being formed, Elephants lived in these countries. But now they are only found in Africa and the East Indies.

There are no large Reptiles in these countries at the present day. But the vertebræ exhibited here were found in a bed of clay in England, and we know that they belonged to an immense Sea-Reptile—the *Ichthyosaurus*, some complete skeletons of which can be seen in the Palæontological Room. The clay in which these bones were found is of the age called Liassic by geologists, and is immensely older than the clay in which the Elephant teeth occur, which is known as Pleistocene.

The Great Ice Age, which occurred during the Pleistocene period, had a great effect on the distribution of Animals. Many parts of Europe, Asia, and America were covered by great sheets of land ice or submerged beneath the waters of a sea covered with floating bergs. Thus many animals were exterminated or driven southwards.

How Distribution Teaches the History of Animal Groups.

The Opossums furnish us with a good example of how a knowledge of the past and present distribution of animal groups enables us to trace their history. Opossums are at present confined to South America and the warmer parts of North America. In the Eocene rocks of Europe, however, their remains have been found; and they also occur in the Pliocene rocks of North America. Hence we know that the Opossums very long ago inhabited Europe, and that their descendants migrated into North America at a later period, probably by a land connection now destroyed. From North America they spread into South America, where they are now found.

THE SIX GREAT REGIONS.

THE distribution of living Mammals and Birds has led to the division of the earth's surface into Six Great Regions. The accompanying map shows the extent of these as defined by Messrs. Sclater and Wallace. The colours used here are used throughout the Collection to identify the various Regions. Although primarily intended to mark out the distribution of Mammals and Birds, these Regions are, on the whole, appropriate to other groups of Animals. It must be remembered that the boundaries between adjacent Regions are not sharply marked off, as they are shown in this map; one set of animals gradually gives place to another as we pass from Region to Region. The cases along this side of the room contain some of the Animals most characteristic of the various Regions.

PALÆARCTIC REGION.

The Palæarctic Region (including Europe, North and Central Asia and North Africa) has been the birthplace of most living groups of animals. Before the cold of the Great Ice Age drove them southwards, there lived here many forms which are characteristic of the Ethiopian and Oriental Regions at the present day. Consequently this Region is poorer in animals than it once was; and it has but few groups absolutely confined to it, because so many of its races have now spread to other Regions. It is very interesting to note that this Region, which has given birth to the most dominant races of Animals, has also been the home of the most dominant races of Men. European Men have now established themselves in Africa, India, and America, as European Animals did long ago.

THE BRITISH ISLANDS

The British Islands form the western outposts of the great Palæarctic Region, which stretches across Europe and Asia eastwards to Behring's Straits. Before considering this region generally, it may be well to note some facts of distribution within our own islands.

Animals of the Celtic Fauna.

These animals represent those older inhabitants of the British Islands which may be appropriately termed members of the Celtic Fauna. They are characteristic of Ireland and of the western and highland regions of Great Britain. They are species which, on the Continent, are found either in Alpine districts or in south-western Europe and the Mediterranean region.

Animals with a Wide Range over the British Islands.

These animals are representatives of those species which range over the whole of the British Islands. They form the dominant members of our fauna, and, if we study their distribution abroad, we find that they are spread over a great part of the Palæarctic Region and in some cases over other parts of the world also.

Animals of the Teutonic Fauna.

These animals represent the newer immigrants to the British Islands, and may be called members of the Teutonic Fauna. They are found in the eastern and lowland parts of Great Britain, and are absent from the mountains, the west, and Ireland, or occur there only as chance visitors. Abroad they have either a wide distribution or are characteristic of Central Europe. It is interesting to note that these species inhabit those parts of our Islands where the men belong mostly to the Teutonic race, while the older fauna are found in those western and hilly regions which are the home of the older Celtic men.

Camels.

The Camel family (*Camelidæ*) includes the true Camels (*Camelus*) and the Llamas (*Auchenia*). There are two species of Camel—the One-Humped (*C. dromedarius*), and the Two-Humped (*C. bactrianus*). Neither species is certainly known in a wild state, but both have been used as beasts of burden from a very remote period over the deserts of the Palæarctic Region, of which they may doubtless be considered characteristic animals. They have lately been introduced into India and Australia. The Llamas occur in both the wild and domestic state in the mountains and southern plains of South America. Their fossil remains have been found in the Pleistocene cave-deposits of California, Brazil and La Plata. Remains of extinct animals which may be regarded as the ancestors of both the Llamas and the Camels are found in the Tertiary rocks of the United States and Mexico. The branch of this original stock which gave rise to the Camels probably passed into Asia by a former land connection north of the Pacific Ocean. The American origin of so typical an Old-World group as the Camels is very remarkable. It is further supported by the fact that fossil Camels from the Sivalik beds of India show an approach to the Llamas in structure.

Reindeer.

The Reindeer is a good example of an animal with a circumpolar range, being found in the northern parts of both the Palæarctic and Nearctic Regions. The American Reindeer (Caribou) cannot be distinguished from the Old-World animal as a distinct species. The Reindeer formerly extended much farther to the south, and its remains have been found in Great Britain and Ireland.

Ethiopian Region.

The Ethiopian Region (including Central and South Africa and Madagascar) presents us with a mixture of ancient Animals (as the Lemurs and Insectivora) with an infusion of more modern types (as the Monkeys and Elephants) which came in from the north. The Island of Madagascar, which was separated from the African continent before this northern invasion, preserves a most remarkable collection of old-time animals.

Lemurs.

(*Sub-order Lemuroidea.*)

The animals belonging to this group, with the exception of five species which are found in the Oriental Region, are entirely confined to the Ethiopian Region, where fifty species of Lemurs occur, and of these no less than thirty-three are found only in the Island of Madagascar. Madagascar may therefore be regarded as the headquarters of the group; and its great development there, together with the total absence from the island of the Apes and Monkeys, would appear to show that Madagascar has been separated from the African continent since early Tertiary times. At that remote period there was probably a tropical continent in which Lemurs were the highest forms of life existing. Subsidence of the land then probably took place, and large tracts of the old continent were submerged beneath the Indian Ocean, leaving Madagascar as an island. The Lemurine animals of the African and Asiatic continents were almost exterminated by the influx of Apes and Monkeys which were driven south by the approach of the great Ice Age. Madagascar, however, being separated from the continent, was not invaded by the Apes and Monkeys, and so its ancient Lemurine inhabitants have survived till the present day.

Hippopotami.

The two living species of Hippopotamus are peculiar to the Ethiopian Region, of which they are among the most characteristic animals. Formerly, however, the group had a much wider range, as fossil bones of these animals have been found as far north as England and as far east as Burmah.

Horses and Asses.

(*Equidæ.*)

Wild horses and asses are now almost entirely confined to the Palæarctic and Ethiopian Regions. Wild asses are specially characteristic of the former region, and the Striped Horses (Zebras and Quaggas) of the latter. The common Horse occurs nowhere in a truly wild condition, but we know from fossil evidence that its wild ancestors roamed over Europe in the early Human period. At the same period wild Horses abounded in North and South America. Through some unknown cause they became entirely extinct, and the herds of Horses which now roam over the Pampas are the descendants of the domestic animals brought from Europe by the Spaniards. A remarkably complete set of fossil remains have enabled us to conclude that the Old-World and American horses were independently developed from five-toed ancestors during the Tertiary periods. The stripes on the domestic Ass, and those which can occasionally be observed on Horses, prove the relationship of our domestic animals to the African Zebras. It would seem that whilst the stripes of the Zebras are of advantage to animals living in the wooded and grassy plains of Central and Southern Africa, the unicolourous coat of the Wild Asses is specially adapted to life in the sandy districts of North Africa and Central Asia.

Oriental Region.

The Oriental Region (including India and Ceylon, Malaya, Sumatra, Java, and Borneo) is remarkably rich in varied and highly-developed forms of animal life. The groups found there occurred formerly in the Palæarctic Region also, but the cooling of the climate in the latter region has caused them now to be confined to the tropical Oriental districts. There is a considerable resemblance between this and the Ethiopian Region, owing to the fact that both have received so much of their animal population from a common northern source.

Oriental Lemurs.

Three genera of Lemurs (the Slow-Lemurs, the Loris, and the Tarsier) are found in the Oriental Region. They are the survivors of what was a dominant group before the immigration of the Apes and Monkeys from the north, and their presence probably shows an ancient land connection between the Oriental Region and Madagascar, in which the great majority of modern Lemurs are to be found.

Rhinoceroses.

Five living species of Rhinoceros are known, three of which inhabit the Oriental and two the Ethiopian Region. They probably reached their present habitats from the north, as fossil remains of Rhinoceros occur in the Tertiary Rocks of Europe and Central Asia, as well as in those of North America. We cannot tell, at present, whether the group first arose in the Old or the New World.

Elephants.

(*Proboscidea.*)

Only two species of Elephant are now living, one of which is confined to the Ethiopian, the other to the Oriental Region. It is clear from fossil evidence that in Tertiary times Elephants abounded in the Palæarctic Region, and so we have in the two modern species the descendants of animals which migrated southwards. It is remarkable how many of the forms which inhabit the Ethiopian and Oriental lands at the present day have been derived from the north. The Mammoth, a great woolly Elephant, was contemporary with prehistoric Man in Ireland, England, and Central Europe. The American continent was also inhabited by Elephants in Tertiary times; but as their remains are found there in deposits of later age than those in which we find them in Europe, we must regard the Palæarctic region as the birthplace of the group.

Australian Region.

The Australian Region (including Celebes, Papua, Australia, New Zealand, and the Isles of the Pacific) have been long isolated from the rest of the world. Most of the groups of animals spread over Asia and Africa have been unable to obtain an entrance here, and consequently we find in this Region a collection of living survivors

of very ancient groups. The Marsupials of Australia, the Tuatara Lizard of New Zealand, the Dipnoid Fish, Ceratodus of the Australian rivers, and the Nautilus of the Australian seas, are types of races which inhabited Europe in the far-off Secondary period, and have long ago given place there before the competition of newer forms.

Marsupials or Pouched Mammals.

(*Order Marsupialia.*)

The Marsupials differ from the higher (Placental) Mammals in their mode of reproduction. The young are brought forth in a very undeveloped condition, and kept for some time after birth in the pouch of the mother. Except the Opossums which inhabit America, the Marsupials are entirely confined to the Australian Region. And with few exceptions all the Mammals within the latter Region are Marsupials. In all other parts of the world Marsupials have been extinct for ages, but their fossil remains prove that they inhabited Europe during the Secondary Period. Whilst the competition of higher forms exterminated them on the great continents, they were protected in the Australian Region, which must have been isolated from the rest of the Old World before the Placental Mammals had become highly developed. In this protected Australian area the Marsupials have been differentiated into a number of groups with varied structures and habits. The Mammals, therefore, which inhabit the Australian Region to-day nearly all belong to a group which has long passed away in other parts of the world. This persistence of ancient groups is very characteristic of the Australian area, which might indeed be called the "Region of Living Fossils."

Egg-Laying Mammals.

(*Order Monotremata.*)

The Duck-billed Platypus and Echidnas, which are entirely confined to the Australian Region, differ from all other Mammals, as they lay eggs, and show by their structure a close relationship to Reptiles. Probably they are the survivors, but little altered, of the ancestral stock from which all other Mammals have sprung.

Australian Placental Mammals.

Except a few Apes and Ungulates in Celebes, an island on the extreme frontier of the Australian Region, the only Placental

Mammals really indigenous to that Region are the Dingo or Native Dog, Rats, and Bats. Rats, owing to their small size, can be transported across seas more easily than larger animals; whilst Bats by means of their power of flight can range widely. It is not easy, however, to suggest the means by which the Dingo reached Australia. Many of the Australian Rats are not found elsewhere, and it is probable that their ancestors migrated thither from Asia at a rather remote period, and became modified in their new surroundings. The Rabbit has been introduced by English settlers, and its rapid and alarming increase proves that if many of the larger Placental Mammals had ever obtained means of transport to Australia, the Marsupials would quickly have been exterminated by their competition, as they have been in Europe, Asia and Africa.

Celebes is an island which is regarded as the western limit of the Australian Region; it is separated by the Straits of Macassar—about 120 miles wide—from Borneo, which certainly belongs to the Oriental Region. The animals inhabiting Celebes give us a mixture of Australian forms with groups characteristic of the Ethiopian and Oriental Regions. It is very remarkable that the non-Australian animals of Celebes are more nearly allied to Ethiopian than to Oriental animals. For example, the Black Ape (*Cynopithecus*) has its nearest relations in the Baboons of Africa. We infer from this that there must have been a connection of Celebes with southern Asia at a very remote period, before the Oriental and Ethiopian types of the present day had become well differentiated from each other. Since then it seems that Celebes has been connected with the Austro-Malayan islands, and thus the mixed character of its inhabitants is explained.

Neotropical Region.

The Neotropical Region (including Central and South America and the West Indies) is the richest of all in peculiar groups of animals. Some of these (the Opossums, for instance) are survivors of very ancient groups extinct elsewhere. Others (as the Humming-Birds) have been developed within the Region, which has evidently been isolated from the rest of the world through long periods of past time. Some of the inhabitants of this Region show an affinity with those of the two Old-World southern Regions—the Ethiopian and Australian. This has been explained by imagining the former existence of a great southern continent over which animals are

supposed to have made their way between South Africa, Australia, and South America. The probable explanation, however, lies in the fact that the groups of animals common to these three Regions are the survivors of races which once ranged over the whole world; and in each case they have probably reached their present habitats from the north.

Edentates.

(*Order Edentata.*)

The Edentates, or Mammals without front teeth, are entirely confined to the Neotropical Region, except two genera, both of which occur in the Ethiopian, one extending also into the Oriental Region. In the Neotropical Region there are now living three families of Edentates: the Sloths, the Armadilloes, and the Ant-Eaters. These three families comprise twelve genera. In Pleistocene times, however, the Edentates were much more numerous in South America than they are now, and many of them attained a gigantic size, such as the *Megatherium*. The extinction of these gigantic forms, and the survival of their smaller relations till the present day, afford a good illustration of the fact that large animals are often less able to adapt themselves to unfavourable changes in their surroundings than are smaller creatures.

Nearctic Region.

The Nearctic Region (including the temperate and Arctic parts of North America) possess an animal population some of whose members (as the Racoons) show affinity with Neotropical, others (as the Bears) with Palæarctic animals. Many of the most typical Neotropical animals formerly also inhabited the Nearctic, but the cold of the Ice Age drove them southwards, and they are now almost or entirely confined to tropical America. Since the Ice Age, some forms, apparently developed within the Neotropical Region, have spread their range over the southern Nearctic. The number of groups (Bears, Deer, Sheep, Dogs) common to the Palæarctic and Nearctic Regions show that there must have been formerly great facility of intercourse between the two, by some old land-connection, now destroyed. In Tertiary times the Nearctic Region was, like the Palæarctic, the home of Elephants and Rhinoceroses, and also of some peculiar gigantic mammals quite different from those living in Europe at that period.

Bears.

Bears are found all over the Nearctic, Palæarctic, and Oriental Regions, and only one species occurs in the Neotropical Region—in the higher Andes. The Nearctic Region has three species of Bear: the Black Bear, the Grizzly, which is very nearly related to the Brown Bear of Europe, and the Polar Bear. The Polar Bear is found on all the shores of the Arctic Ocean, and is a good example of the circumpolar animals, which, specially adapted to life amid Arctic surroundings, are characteristic equally of the northern Nearctic and of the northern Palæarctic Regions.

Bisons.

There are two species of Bison, one characteristic of the Nearctic and the other of the Palæarctic Region. Both are now almost extinct; the gradual process of destruction of the American species is shown on the annexed map. The Old-World species formerly extended over the greater part of Europe; its survivors are now preserved in a few forests in Austria and Russia.

Elks.

The Elk (*Alces*) is a characteristic northern genus of Deer with only one species, which is spread over part of the northern districts of both the Nearctic and Palæarctic Regions.

Tailed Amphibians.

(*Urodela.*)

The Tailed Amphibians are specially characteristic of the Nearctic and Palæarctic Regions; only a few species range southwards into the tropical districts of America and China. Two of the five families of Tailed Amphibians are confined to the Nearctic Region; the other three are almost equally divided between that Region and the Palæarctic. The high antiquity of the group makes its almost complete absence from the Tropical Regions very surprising.

COLLECTION TO ILLUSTRATE THE HISTORY OF ANIMALS.

This collection is meant to illustrate those facts of Animal Life and Structure which teach us the History of Races.

Animal Groups.

Species.

Naturalists speak of each distinct kind of animal as a *species*. For instance, the Hooded Crow is a different *species* of bird from the Rook: besides the evident difference in colour, there is a difference in the relative lengths of the wing-feathers; also the face is naked in the adult Rook, but feathered in the Crow. The two birds, however, are so alike in their structure that they are placed in the same *genus* (*Corvus*). The Rook is called *Corvus frugilegus*, the Hooded Crow *Corvus cornix*. Species belonging to the same genus are said to be nearly related to each other; and are believed to have descended from common ancestors at a not very remote period.

Genus.

The Magpie differs sufficiently from the Crow and Rook to be placed in another genus (*Pica*): the tail of the Magpie is longer and its wings shorter than those of the Crow. Such a difference in structure shows us that the relationship between the Magpie and the Crow is more distant than that between the Crow and the Rook.

Family.

Though the Magpie differs from the Crow sufficiently to be placed in another genus, the two birds have enough in common to be classed in the same *family* (*Corvidæ* or Crow family). All birds of this family have the beak thick, with the chin-angle far forwards. The Thrush, however, belongs to another family (*Turdidæ* or Thrush-Family), characterised by a slender beak with the chin-angle not so far forwards.*

Order.

The Skylark belongs to yet another family (the *Alaudidæ* or Larks). The Larks have the beak much shorter and thicker, proportionally, than Thrushes, but they agree with the latter

* This is illustrated by diagrams.

and not with the Crows in the position of the chin-angle. But the Crows, Thrushes, and Larks all agree, with many other families, in the structure of the foot, which has the first toe directed backwards, and provided with a claw longer than those on the other toes. This arrangement gives these birds great power of perching on branches of trees. They all belong to the same *order* (*Passeres* or Perching Birds), and are believed to be really, though somewhat distantly, related to each other.

The Kestrel is a bird differing considerably from all these: its hooked beak and strongly-clawed foot are specially adapted for killing and feeding on small animals; it is classed in another *order* (the *Accipitres* or Birds of Prey).

Class.

The Tern is evidently very different both from the Perching Birds and from the Birds of Prey. Its webbed feet show its adaptation for life on the water; it belongs to the order of Sea-Birds (*Gaviæ*). Yet the Crow, the Kestrel and the Tern all agree in the main points of structure and life-history; they are all members of one great *class* (*Aves* or Birds); and the unity of essential points is believed to indicate that at a very remote period lived an ancestral group of birds from which the various living orders of birds have descended.

The Chameleon belongs to another class (*Reptilia*). Reptiles differ from Birds in having the front limbs developed as legs instead of wings, in being covered with scales instead of feathers, and in possessing teeth in their jaws. Yet we know that the birds of long-past ages had teeth and resembled Reptiles in other ways. Reptiles and Birds are both developed from eggs in a very similar manner, and, distinct as they are now, they are believed to have had a common origin at a very remote period.

Phylum

(or Sub-Kingdom).

The Stoat differs from the Bird and the Reptile in being clothed with hair instead of with feathers or scales, and in having been nourished with milk when young. It belongs to a distinct class (*Mammalia*). Yet the Mammal, Bird and Reptile all agree in having a backbone and hard skeleton inside their bodies; they all belong to the same *phylum* or great primary division of the animal kingdom (the *Vertebrata*). We learn from this that between them all there is some relationship.

But the Crab differs in the whole plan of its structure from these animals. It has no backbone, and its hard skeleton is

formed, not within the body, but from the outer skin. Instead of the four limbs found in Vertebrates, it has a number of pairs of many-jointed limbs. It belongs to quite another *phylum* (the Arthropoda). There probably is some relationship between the Crab and the Vertebrates, but it is a very distant relationship indeed.

Variation.

Though most species can be readily defined and distinguished from all others, yet many show very great variation. We may find two animals quite unlike in colour or size, and yet we refer them to the same species if there are known to be intermediate forms connecting them. But if no such intermediate forms exist we say they are of different species. It is believed that species of the same genus, though distinct now, were once connected by intermediate forms which have died out. And it is also thought that new species will be formed by the dying out of some of the varieties of those species which now show great variation. Examples of some variable species are shown here. The variation which they and all others exhibit is the first great fact, which throws light on the Evolution or History of Animal Races.

The Struggle for Existence.

Rate of Increase in Numbers.

The rate of increase among Insects is very great. A single Flesh-Fly produces 20,000 eggs, and the egg is developed into a fly within a fortnight. It has been calculated from this that if all the offspring of a single fly were to survive and multiply they would amount to a hundred millions of billions in a single summer. It is noteworthy that among the Insects where we find the highest rate of increase in numbers we find also the greatest number of species. This seems to show the connection between the struggle for existence and the production of new kinds of animals.

Natural Selection.

The rate of increase in numbers among all classes of animals is so great that many times more young are produced than can possibly survive, because there is not enough food for all, and also because many fall victims to accidents or to the attacks of

other animals. This rapid multiplication of numbers leads to a constant struggle for existence between animals of the same and of different species. It is clear that any animals which undergo variation, enabling them to protect themselves and get food more readily than others, will consequently be more likely to survive. The struggle for existence kills off the unfit and preserves the fit. "Natural Selection" is the term by which this process is generally known. It is believed to be the chief means by which the different groups of animals have been separated off from each other, successive generations through long ages having become more and more fit for their special mode of life, and so having diverged more and more from their common ancestors.

Ways of Gaining Livelihood.

The Squirrel and the Cockchafer are examples of the very large number of animals which feed on fruit, leaves, or other vegetable substances. The food-supply of such animals depends on the richness of the vegetation around them, and any scarcity of plants will therefore make it difficult for them to get a living, and so increase the severity of the struggle for existence.

The Sparrow-Hawk killing the Thrush, and the Spider catching the Fly, are examples of those animals which live by preying upon others. The struggle for existence affects both the devourers and the species upon which they feed; the former becoming continually better adapted for hunting, and the latter for escaping from their pursuers.

The *Sacculina* gets its living by attaching itself to the abdomen of a crab, and drawing nourishment from the tissues of that creature by means of root-like suckers. It is said to be a "parasite," and the crab is called its "host." Animals which live as parasites are numerous in many groups. Parasites get shelter and food very easily, drawing ready-made nourishment from their hosts. But this luxury always leads to degeneration, and we find that parasites are often without limbs or sense organs, as they can get food without seeing, hearing or moving.

Structures for Offence and Defence.

Hard structures for defence are developed from the outer skin of many animals. The spines of the hedgehog and the shell of the snail are familiar examples of such armour. The great

service of these structures to their possessors in the struggle for existence is evident.

The great canine teeth of the Tiger and the poison jaws of the Centipede are examples of structures for offence, serving their possessors either to capture and kill their prey or to fight their enemies.

Instincts for Defence.

Animals are by no means dependent only on their bodily structure or offensive power for success in the battle of life. Instinct, intelligence, and moral qualities are of greater importance.

The habit of constructing nests is common to many groups of animals. The beautifully made nest of the Trap-door Spider serves not only as a shelter for parent and young, but also as a means of catching prey.

Some Fishes make nests and care for their eggs and young.

The male Stickleback constructs a nest of water plants, etc., in which the female deposits her eggs. He continues to guard the nest until the eggs are hatched and the young fishes able to take care of themselves. The female takes no further heed to the eggs after laying them, so we have here an example of the father, not the mother, being the nursing parent.

The nest-building habit is specially characteristic of the higher birds. It is evident that the shelter thus afforded to the young and the care taken of them by the parents are very advantageous to the preservation of the species.

Crabs are much sought after as food by fishes. Some Spider-Crabs carefully tear away pieces of seaweed and zoophytes, and stick them over their bodies and limbs. By this means they obtain concealment and escape the observation of their enemies.

The Hermit-Crabs use empty whelk-shells as protective coverings. The hinder part of the body of these crabs is quite soft: they have evidently lost their own hard armour by their habit through long ages of seeking shelter in the cast-off shells of whelks. When a Hermit-Crab grows too large for its whelk-shell it seeks another and removes into it. A very striking protective habit of the Hermit-Crabs is the use they make of Sea-Anemones. These creatures, being armed with stinging-cells, are very obnoxious to fishes; the Crab fastens a Sea-Anemone on to his shell, and, thanks to his unpleasant companion, escapes molestation. The Sea-Anemone, being carried about, gets the benefit of fresh water and food supplies. Hence the partnership is advantageous to both animals. Such

an association of different creatures for their mutual benefit is known as *symbiosis*.

Another habit highly valuable to animals is the formation of social communities. This is exhibited in a very low group, the Hydroids, where we find colonies in which each individual contributes to the protection or feeding of the whole community.

The habit of living in companies is followed by many caterpillars, as those of the small Ermine Moth. These spin a nest of web over their food-plant, which serves as a protection to the colony of caterpillars, and afterwards to the white cocoons, within which they turn to chrysalids.

Among some Insects the social instinct is combined with great skill in nest building and careful tending of the young. The Queen Bee (the only fertile female in the colony) lays her eggs in the cells formed by the barren females or workers. In these cells the workers store food for the grubs, which will hereafter become bees.

This picture of a group of African Monkeys shows the social instinct and care for young among one of the highest groups of animals. The Monkeys have been plundering a maize-field. The sentinel on the fence has given the alarm to his companions, who are making their escape with their booty, the mother helping her young ones to avoid the threatened danger.

It is interesting to note that in the higher groups of each great class of animals the struggle for existence becomes less selfish, and the social instincts and care for young become more and more developed.

Concealment by Colour and Form.

The action of Natural Selection in modifying animals is very evident in some of the facts presented by their colour and form. We often find that the appearance of an animal is specially adapted to conceal it. This concealment serves either to protect a weak creature from its enemies, or to enable a hunter to creep unobserved on its prey.

The colours of Fishes are generally in harmony with the bottom of the water where they live. Many fishes are known to have the power of changing their colour to suit changes in their surroundings.

Very many Birds have their plumage of a mottled hue, like that of the Partridge. Such a combination of tints is never conspicuous among vegetation, and the bird thus escapes the observation of its enemies.

A large number of northern Mammals and Birds, which are

brown or dark-coloured in summer, turn almost or entirely white in winter: the Mountain Hare and Willow Grouse are good examples of these. The object of this change is to obtain concealment among the winter snows.

The spots or stripes on the skin of the Leopard, Tiger, and other beasts of prey make them inconspicuous among the forests and jungles where they live, as these markings harmonise with the shadows cast by trees and long grass. In the twilight, when these creatures are out hunting, their appearance is still less conspicuous than in broad daylight, and they are thus able to approach their prey unnoticed.

Among Insects concealment by colour and form is brought to its greatest perfection. Very many caterpillars have an appearance closely resembling their surroundings: for example, that of the Crimson Under-wing Moth, which, when it stretches its body straight out, looks like a lichen-covered twig. The perfect insect also, when at rest, with its mottled grey forewings hiding its brilliant underwings, is hardly to be distinguished from the lichen-covered bark.

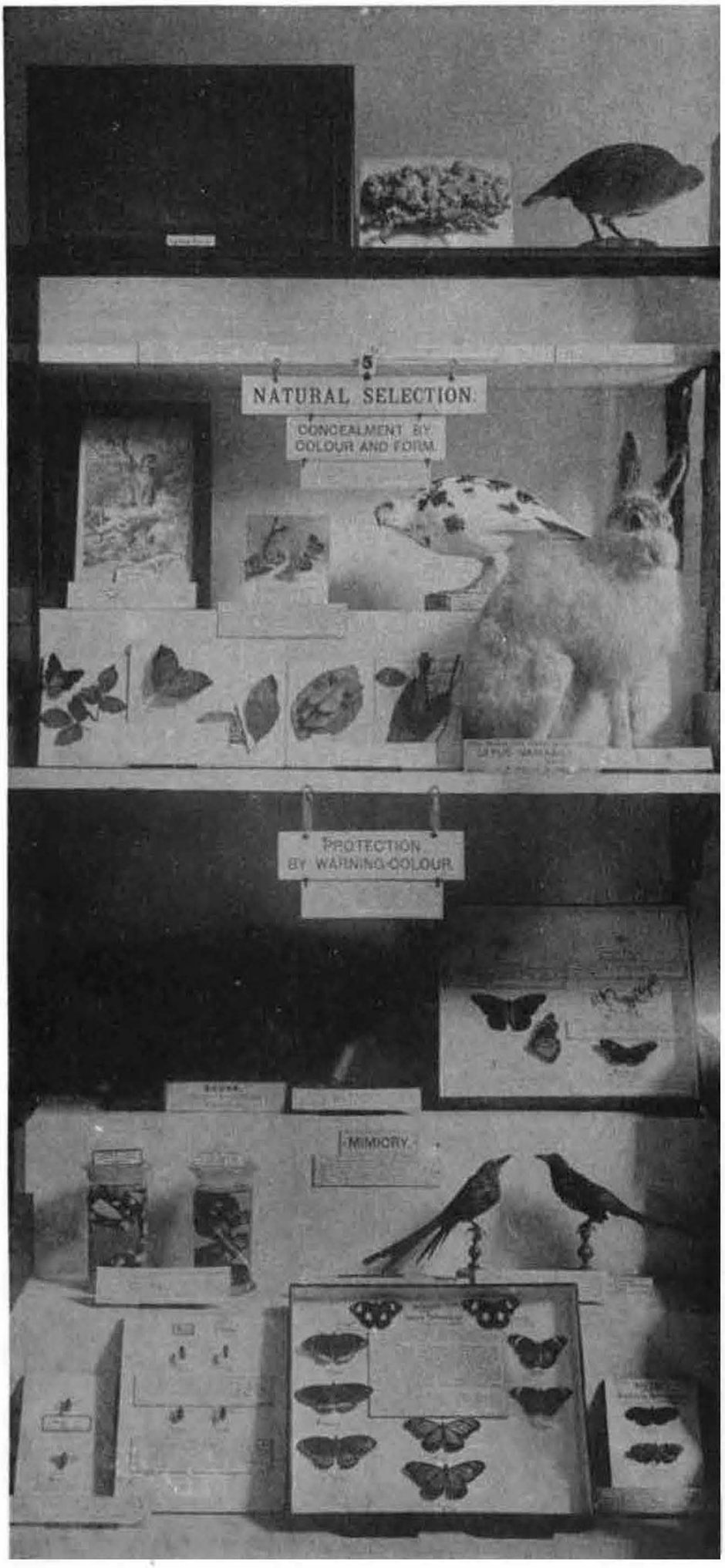
Most Butterflies, instead of having the upper surface of their forewings visible when at rest, like Moths, hold their wings upright above the back. Thus the upper side, which is generally brightly coloured, is hidden, and the lower surface, which is generally inconspicuous, is exposed to view. Contrast the bright upper surface of the Tortoiseshell Butterfly (*Vanessa polychloros*) with the dingy appearance of the same insect when at rest upon a plant, where it will hardly be noticed at all.

In the Indian Leaf Butterfly (*Kallima inachis*) the undersides of the wings are exactly imitative of a withered leaf, the pointed "tails" of the underwings representing the stalk.

Very striking likeness to a leaf is also seen in the Leaf-Insect (*Phyllium*) and the nearly-related Praying-Insect (*Mantis*). The former is a plant-feeder, and its colour and shape are protective. The latter feeds on smaller insects, and hence its resemblance to a leaf enables it not only to escape the observation of its enemies, but also of its prey.

Protection by Warning Colour.

Some animals, instead of being so coloured as to be hidden from their enemies, are adorned with startling contrasts of colour, and so made as conspicuous as possible. These creatures possess some offensive or nauseous quality; their "Warning colour" serves as an advertisement of this, and



Collection to Illustrate

THE HISTORY OF ANIMALS.

This Collection is meant to Illustrate those facts of Animal Life and Structure which teach us the History of Races.

so they escape molestation. On the other hand, weak animals with a concealing coloration are nearly always attacked and devoured by their enemies, if observed.

The Skunks, if annoyed, have the power of discharging an intensely nasty fluid. Their startling black-and-white colour makes them very conspicuous, even at night, and other animals learn from their appearance to let them alone.

Bees, Wasps, and other insects provided with stings, are nearly always adorned with conspicuous bands of black and yellow or red. Insect-eating animals learn by experience to associate these colours with stinging insects and to leave them unmolested.

Other Insects are protected by the possession of nauseous juices, which render them distasteful to insect-eating animals. The family of Butterflies known as the *Danaidæ* furnish an example of these. They are all adorned with startling contrasts of black and white, red, yellow or orange.

The Magpie Moth (*Abraxas grossulariata*) is distasteful to birds in all its stages, and is therefore made conspicuous by its black, white and yellow colours.

The Ladybird Beetles (*Coccinellidæ*) are protected by a nauseous taste and smell, and are rendered very conspicuous by their black spots on a yellow or red ground.

Mimicry.

Examples have been given of the action of Natural Selection in producing colour for concealment, or for advertisement of noxious qualities. A still more impressive result of its action is afforded by some animals of a weak and inoffensive nature, which have become altogether unlike their near relatives, and have adopted the appearance of aggressive or noxious groups. This imitation of protected animals is known as "mimicry."

The Drongos are a dominant group of Indian birds of very aggressive habits. Their glossy black plumage and forked tails are closely imitated by a species of Cuckoo. The Drongo and Cuckoo look very much alike, but the structure of their feet shows that they belong to distinct orders. It has been suggested that the Cuckoo, by its likeness to the Drongo, is enabled to lay its egg in the latter's nest, but this is not certain.

The stinging Hymenoptera (Bees, Wasps, etc.) are mimicked by many other insects. The Moth *Trochilium apiformis*, with its wings almost devoid of scales and its black-and-yellow body, has quite a wasp-like look, and often escapes molestation by being mistaken for a Wasp.

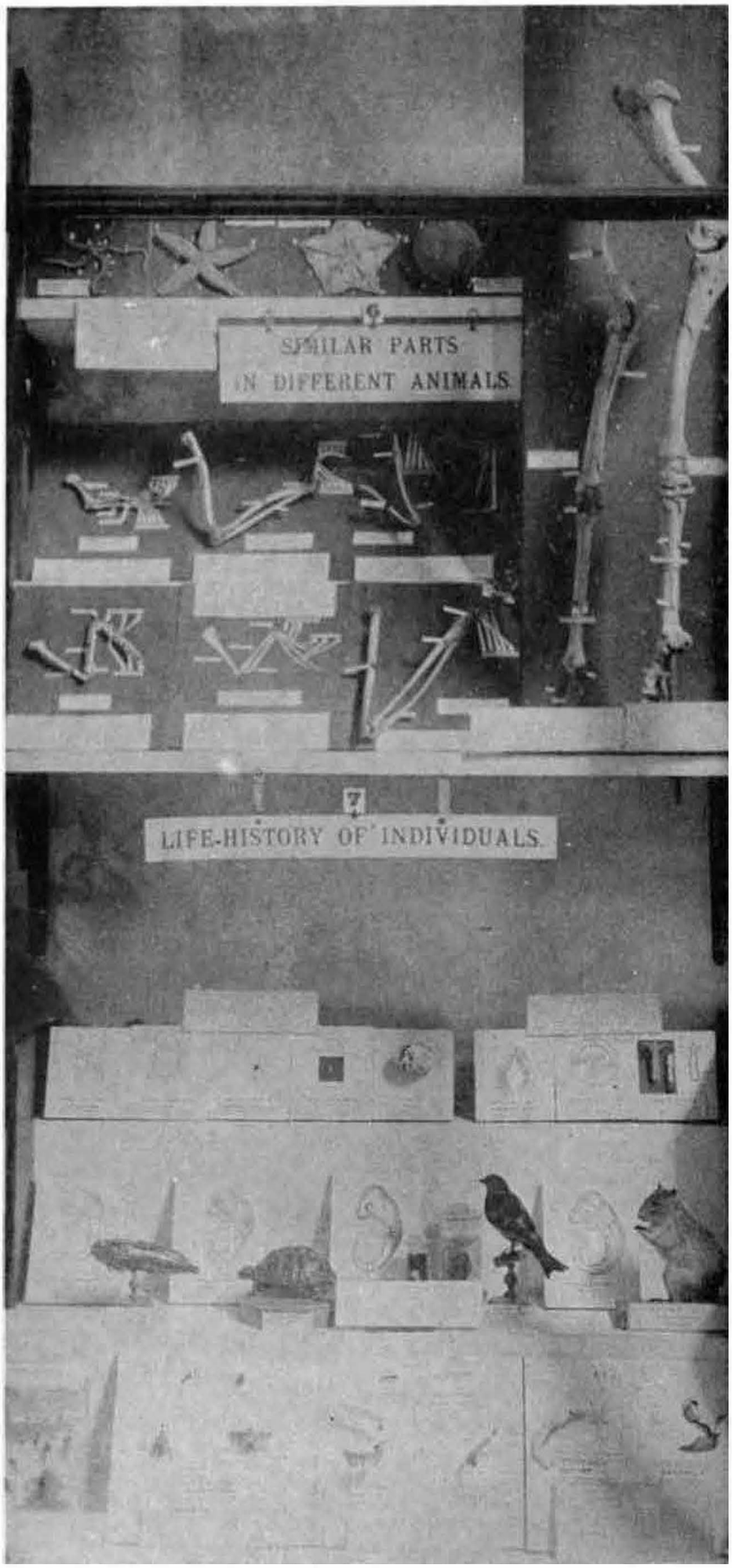
The Drone Fly (*Eristalis*) is frequently mistaken for a Bee, which it closely mimics in colours, build, and habit of buzzing. Yet it belongs to a distinct order, having but two wings while the Bee has four. Of course it has no sting, but its bee-like appearance would probably make its enemies believe that it has.

Another two-winged Fly (*Volucella bombylans*) closely resembles a species of Humble-Bee (*Bombus lapidarius*). The Fly, on account of this resemblance, is able to enter the Bees' nests unmolested and lay its eggs there, so that its grubs, when hatched, may prey on those of the Bees. Such mimicry as this has been called "aggressive," in distinction to those instances where the object sought is protection only.

The *Danaidæ*, and other Butterflies which are distasteful to insect-eating animals, and adorned with warning colours, are mimicked by Butterflies of other families. There are two species of Nymphalid Butterflies common in India (*Hypolimnas bolina* and *H. misippus*), the males of which are very much alike. The female of *H. bolina* is much duller than the male, and is an imperfect mimic of the Danaid insect *Euplœa core*. The female of *H. misippus* is still more unlike her mate, and is an almost exact copy of *Danais chrysippus*. The occurrence of cases of imperfect mimicry is very instructive, as they prove that the more striking resemblances have been arrived at by slow stages. There are species intermediate between *Hypolimnas bolina* and *H. misippus*, in which the females' wings are partly of the dull brown hue of the former insect, and partly of the bright tawny colour of the latter. *Euplœa core* is also mimicked by a *Papilio* (*panope*), and another *Papilio* (*govindra*) mimics *Danais tytia*. These insects are believed to escape pursuit by insect-eating animals on account of their likeness to the nauseous Danaids. In those cases where the female only is protected by mimicry, it is thought that the swifter flight of the male renders such protection unnecessary for him, whilst the female is specially liable to be attacked when laying eggs.

Poisonous Snakes are often adorned with startling colours, which warn their enemies to keep at a safe distance. The Snake *Oxyrhopis trigeminus* is quite harmless, but it resembles very closely in its markings *Elaps tremniscatus*, a poisonous species belonging to quite a different family. Several cases are known of harmless serpents adopting the appearance of their poisonous relations, and thus frightening their foes.

To render these examples of mimicry clear, the noxious animals are in all cases indicated by *red-bordered labels*, and



Collection to Illustrate

THE HISTORY OF ANIMALS.

This Collection is meant to Illustrate those facts of Animal Life and Structure which teach us the History of Races.

the creatures which obtain protection by their resemblance to these by labels with a *blue border*.

Similar Parts in Different Animals.

The various parts of all animals of the same Phylum are formed by modification of some common type. This fact is strong evidence of the descent of the animals from a common ancestral stock.

The Echinoderms all exhibit a radial type of structure, their parts being arranged around a central axis. The number of radii varies, but it is generally five. In the Brittle Star (*Ophiocoma*) the five radii (R) are evident, but the inter-radial areas (I) are very slightly developed. In the Starfish (*Astrias*) the inter-radial areas are more developed, whilst in *Palmipes* they fill up most of the spaces between the radii. In the skeleton of the Sea Urchin (*Echinus*), which might be imitated by tucking in the edges of a Palmipes, the inter-radial areas are much larger than the radii. Thus we find that structures which are but poorly developed in one animal may be of the greatest importance in another of the same group. The corresponding parts of the different animals are said to be homologous.

The limbs of land Vertebrates, though modified for various uses, can all be traced to a common type. The fore limb consists in all cases of a single bone in the upper arm (*humerus*), two bones (*radius* and *ulna*) in the lower arm, a number of small *carpal* bones at the wrist joint, and five or fewer *metacarpal* or palm bones, at the end of which are the *phalanges* or finger bones.

The arm (or front leg) of the Lizard shows a primitive and typical form of limb, in which the normal number of fingers (five) are present. The palm is flat and used for walking, and the arrangement of the radius and ulna does not allow the hand to be turned over.

The primitive five-fingered hand is preserved in several groups of Mammals, including the Primates, to which the Monkeys and Man belong. The principal bones of the Monkey's arm and hand can be seen to correspond almost exactly with those o the Lizard. But the hand of the Monkey can be used for grasping, whilst the radius can revolve around the ulna, and so cause the hand to turn over.

The five-fingered hand is also found in the Bat; but here the fingers are immensely lengthened to support the flying mem-

brane, the arm being used as a wing. The ulna is very much reduced. The thumb is not used for attachment of the flying membrane, but, being provided with a claw, is used by the animal for suspending itself.

The fore limb of a Bird is modified for flying in quite a different way from that of a Bat. The radius and ulna are both well developed. Only three metacarpals and fingers are present, the first metacarpal being very short, and the thumb having only one joint, rarely two. The second and third metacarpals are joined at their extremities. The second finger has two (very rarely three) thick joints, whilst the third finger has only one very small joint.

In the extinct Lizard-like Bird *Archæopteryx*, whose remains are preserved in the Secondary (Jurassic) rocks, there were three fingers, but all were well developed, not joined together, and bearing claws. Hence the wing of *Archæopteryx* (the oldest known bird) stands half way between the arm of a lizard and the wing of a modern bird. A few modern birds have claws on the first two fingers, like *Archæopteryx*. These facts suggest the descent of birds from reptilian ancestors.

The arm of the Sloth is specially adapted for clinging to branches of trees. The first and fifth metacarpals are greatly reduced, and their fingers are quite wanting, whilst the three middle fingers are largely developed and provided with powerful claws.

Instead of walking on their palms and soles, many Mammals walk on their fingers and toes. The fore-limbs of the Deer and the Ass are given as examples of these. In the Deer the humerus is short and stout; the ulna is much reduced, and quite incapable of movement in relation to the radius; the third and fourth metacarpals are joined to form a single long bone, whilst their phalanges form the cloven hoof. The second and fifth fingers are represented by slight vestiges, whilst the thumb has entirely disappeared.

In the Ass also the humerus is short and stout; the upper part of the ulna, which alone remains, is fused with the radius; the third metacarpal with its finger alone supports the limb, the second and fourth being reduced to the small splint-bones, and the first and fifth being entirely wanting. It will be observed in both the Deer and Ass that the joint of the fore limb generally known as the "knee" is really the wrist. Widely as these limbs differ from the typical arm, with its five-fingered hand, a series of connecting forms can be obtained which leave no doubt of their derivation from that type.

LIFE-HISTORY OF INDIVIDUALS.

An animal begins its life as a single cell. The lowest animals (*Protozoa*) remain single cells all their lives. In other animals (*Metazoa*) the original cell (ovum or egg cell) gives rise to a more or less complicated system of tissues and organs. The egg of some animals (starfish, cat) is extremely small, that of others (moth, bird) is rendered large by the presence of a quantity of yolk, which furnishes food for the growing embryo. As each individual higher animal springs from a single cell, so it is believed that all the races of higher animals have sprung from protozoan ancestors. The history of the individual represents that of the race.

An early stage in the development of animals is what is called the *gastrula*. This is a sac inclosed by two layers of cells (*ectoderm* and *endoderm*), opening by a hole (*blastopore*). In cases where the egg has much food-yolk, the primitive form of the gastrula is disguised.

Animals belonging to the Cœlenterata, the lowest group except the Protozoa, remain all their lives in a condition very similar to a gastrula, their body-wall being composed of two layers of cells (*ectoderm* and *endoderm*). Cœlenterates, therefore, show a stage of structure long passed by by the higher groups.

Vastly as a fish, a tortoise, a bird and a rat differ from each other, their embryos at certain stages are so alike that an experienced naturalist might be unable to distinguish them. This striking similarity in their young stages is strong evidence that these animals are really related to each other. The gill-slits, and the vessels which supply the gills with blood in the adult fish, are represented in the embryos of the land animals, though they disappear as development proceeds. We conclude from this that the land animals are descended from aquatic ancestors.

Many young animals are hatched or born in a condition resembling the adult, but some only complete their development after leaving the egg; these latter are said to undergo a *metamorphosis*. When first hatched, such an animal is called a *larva*.

The young of the frog is at first a fish-like larva or tadpole, breathing by gills, provided with a long tail, and without visible limbs. As it grows, the tail shortens, the limbs lengthen, and

the gills disappear; the creature becomes fitted for breathing air. Here, again, the history of the individual is believed to show the evolution of the race, the descent of the amphibians from fish-like ancestors.

No insect possesses wings when first hatched. The cockroach, as well as many other insects, begins its free life as a creature with six legs, but no wings. Before hatching, however, there are more than six legs, but most of these soon disappear. We infer from this that such insects are descended from wingless ancestors with six legs, and, still more anciently, from worm-like ancestors with many legs.

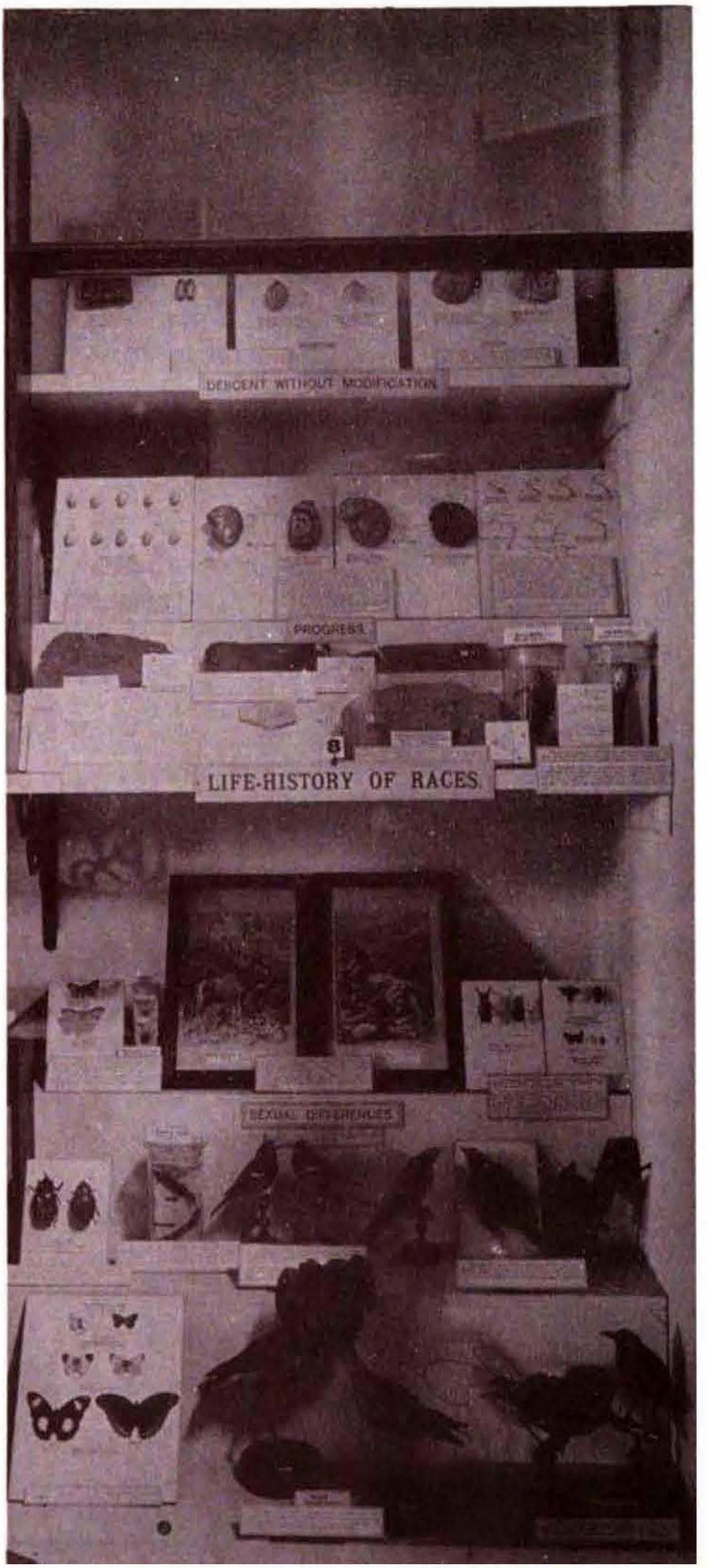
In a caterpillar, which is the young stage of moths and sawflies, there are more than six legs, and the creature has a wormlike aspect. Hence the larva of these high insects recalls the far-off ancestors of the group, and shows a similarity in form to the centipedes and *Peripatus*, their lowest living relations.

Most Crustaceans develop with a metamorphosis. The earliest form of larva is called a *nauplius*, and has three pairs of limbs. As this larva occurs in very many groups, it is believed to represent the ancestral stock of all Crustaceans. The Shrimp *Penæus* is developed from such a larva; other Shrimps, as well as Crabs and Lobsters, are hatched in a later stage of development.

The young larva of the Barnacle is also a nauplius, but its metamorphosis, instead of showing progress, shows degeneration. The larva in a later stage fixes itself by the head and loses its eyes; the body becomes covered by a system of plates, and the legs, now useless for locomotion, serve to kick food into the mouth. In the adult, the head-region elongates to form the stalk. The interesting fact that the Barnacle starts from the same larval form as the Shrimp shows us that the history of some individuals and races is Degeneration and not Progress.

Life-History of Races.

In addition to the information given by the life-histories of individual animals, we have that afforded by the remains of animals which lived on the earth in past ages. These remains are known as fossils, and are found imbedded in various rocks. By their aid we are able to speculate as to the life-history of races.



Collection to Illustrate

THE HISTORY OF ANIMALS.

This Collection is meant to Illustrate those facts of Animal Life and Structure which teach us the History of Races.

Descent without Modification.

Some types have come down from a remote antiquity with hardly any alteration in structure. The lamp-shells (Brachiopods) afford examples of such. The genera *Lingula* and *Terebratula* occur in very old rocks, the former in some of the oldest in which fossils have been found; yet both survive until the present day.

The Oysters cannot be traced back so far, but they have survived, with very little change, since the Secondary period of geological history. (Geologists classify rocks containing fossils into Primary, Secondary, and Tertiary groups, the first being the most ancient.)

Progress.

The series of Pond-Snails (*Paludina*) shows how a species may be changed into another form in course of time. These shells are taken from beds of rock formed in an ancient lake in Slavonia. No. 1 is from the bottom (oldest) bed, the others successively from newer beds, and the gradual change from a plain to a ribbed shell can be seen to have taken place. We have here in a comparatively short space of geological time the change from one species of a genus into another.

If we extend our observations over a longer period of geological time, we can perceive greater changes: the transformation of one genus into another. In the Primary rocks, known as Silurian, Devonian, and Carboniferous, the shells of a genus of Cuttles, *Goniatites*, are found; these shells are divided into chambers by folded partitions (A*). In the early Secondary (Triassic) rocks, another genus (*Ceratites*) appears, in which the partitions between the chambers are more complicated (B). In the middle and later Secondary rocks (Jurassic and Cretaceous) we find the Ammonites, in which the partitions are still more complicated (C). It is very interesting to note that in young Ammonites the partitions are in simple folds, so that here again the life-history of the individual, as far as is known, represents that of the race. The Ammonites are not found in rocks later than the Cretaceous, so the race has long been extinct.

A remarkable series of fossils from the Tertiary rocks of North America enables us to trace the changes from a primitive five-fingered and five-toed animal to the modern Horse. It will

* References to diagrams of partitions which accompany the specimens.

be seen that, as we pass from the *Phenacodus* (an animal as large as a leopard) of the oldest Tertiary beds to the Horse of the present day, we observe an increase in the size of the animal, a decrease in the relative length of the humerus, a shortening of the ulna and its fusion with the radius, and a great increase in the length and strength of the third metacarpal and phalange, while the other phalanges entirely disappear, and remnants of the second and fourth metacarpals alone remain as the "splint-bones."

Geologists divide the Tertiary Rocks into Eocene (most ancient), Miocene, Pliocene and Pleistocene (most recent) divisions.

The study of fossil Fishes enables us to trace the change from one order to another. In very old rocks (Silurian and Devonian) we find remains of fishes of the Ganoid order, fishes covered with large bony or enamelled scales, represented at the present day by a very few survivors (sturgeon, gar-pike). *Osteolepis* is one of these ancient fish; it has a tail (A) of the most primitive form, with fin-rays above and beneath the backbone (see sketch) supporting a nearly even tail-fin. Such a tail is called diphycercal; it may be found in a few living fish—some of the African Ganoids, for instance. In this series, changes in the form of the tail are specially dwelt upon, because these are the most easy of observation.

Palæoniscus represents the Ganoid fishes of a rather later period; its remains are found in Upper Primary (Permian) rocks. Its tail (B) is uneven (heterocercal) in form; the backbone runs through to the tip of the upper fin-lobe, and the rays above it (*a*) are much shorter than those below (*b*) (see sketch). Such tails were found in some fishes at an earlier period, and are characteristic of sturgeons, sharks and some other living fish.

In *Pholidophorus*, a Ganoid from the Lower Secondary (Lias) rocks, we find a tail (C) with the backbone not carried to the end of the fin, and with the two fin-lobes of nearly equal size. The turning up of the backbone towards the upper lobe can, however, be clearly seen. This is a masked heterocercal tail.

Leptolepis, from the Middle Secondary (Oolitic) rocks, represents the group of fishes which connects the Ganoids with the Teleostean order to which belong the great majority of modern fish. Authorities cannot decide in which order this group should be classed. The tail (D) of *Leptolepis* resembles that of *Pholidophorus* in form.

In the Upper Secondary (Cretaceous) rocks we find the

oldest known Teleostean fishes. *Osmeroides* is an example of these. Its tail (E) has lobes of equal size (homocercal) and the backbone ends in a series of enlarged joints whence the fin-rays arise (see sketch).

The group to which *Osmeroides* belongs stands midway between the living Salmon family (*Salmonidæ*) and Herring family (*Clupeidæ*). It shows the connection of these living fishes with their more remote ancestors.

All Teleostean fishes have homocercal tails, but in the course of the development of each salmon or herring, its tail is first diphycercal and then heterocercal; in young fish the remains of the primitive rod (notochord) from which the backbone was formed can be seen running into the upper tail-lobe. Here, again, the history of the individual represents that of its race.

Sexual Differences.

The male and female of the same animal are often found to differ considerably in outward form and appearance. The causes which have led to this divergence are a very interesting study.

With regard to the relative size of the sexes, in most groups of animals the male is smaller than the female. The moth and spider exhibited illustrate this. It may probably be explained by the greater freedom and activity of the male, his mate having to produce and carry eggs.

In the class of animals (Mammals) to which man belongs the male is, on the other hand, generally larger and stronger than the female. Very often he possesses structures for combat not developed in his mate; the antlers of the stag and the mane of the lion (which serves as armour for his neck) are examples of such. They have been developed in the males only, because these fight with each other for the possession of the females, and have afterwards to defend their mates and young. The young males are without these structures: this shows that the adult males did not always possess them.

Among insects, the males are often provided with structures which are wanting or less highly developed in the females. The mandibles of the male Stag-beetle are far larger than those of the female.

Insects whose males are winged sometimes have the females wingless, or possessed of the merest remnants of wings, which show that these organs were functional in their ancestors. The Cockroach and "Vapourer" Moth are examples of such. The female Cockroach makes up for her want of flight by her

power of rapid running, but the contrast between the two sexes in the "Vapourer" is an extreme illustration of the tendency of the male to be active and the female passive.

The presence of ornamental structures or colours in the male only is notable in several groups of animals. The strangely shaped horns on the thorax, found in certain groups of beetles, are examples of such.

The male Newt resembles the female except in the breeding season, when he develops a handsome crest and becomes ornamented with spots. The fact that such adornments appear only at the breeding season has led to the explanation that they are the result of the selection through many generations of the handsomest males by the females as mates. This theory is known as "sexual selection."

The Chaffinch is a common bird, and affords a good example of male ornamentation, the cock bird being much more brightly coloured than his mate, especially during the breeding season. When young he closely resembles the hen bird.

In addition to the action of "sexual selection" in increasing male adornment, natural selection has no doubt operated in these cases to keep the female of a sober hue, as bright colour would be dangerous to her when sitting on the eggs.

The large collar of feathers developed by the male Ruff at the breeding season is a striking sexual ornament: it serves not only as adornment, but as armour, for the cock birds fight for possession of the hens. At other times of the year the male bird is much like the female.

The Birds of Paradise show extremely striking sexual differences, the male being adorned with bright colours and fantastically shaped feathers, while the female is as dull in hue as one of our common woodland birds.

THE PRESIDENT: "For the first idea of having a section illustrating the geographical distribution of animals in this Museum, we are indebted to America—to the Museum at Cambridge, Boston, where Professor Agassiz has done this on a very large scale. In 1884 I had an opportunity of visiting that Museum, and I was very much struck with that particular section. There are rooms devoted to regions. You go into a room and you find yourself surrounded by the characteristic fauna of the region which the room represents. We desired to carry this out, but for some years we were not able to

do so, until about three years ago, when it was undertaken by Mr. Carpenter, and I am sure you will all agree that he has carried out the work in a most successful and attractive way. For my part, I have one objection to one particular, that I think we have only temporarily adopted, and that is making the use we do of the skeletons of large mammals. They would be better employed in illustrating the structural and osteological details of animals rather than in representing living animals. I am inclined to think that as a permanent appointment it would be desirable that these skeletons should not be put in as representing the fauna of a region. At present we have not room enough to carry out the idea of having a separate section, and for the present it probably answers to have the skeletons in the double capacity, as representing what they do—the structural features of these animals, and also representing the animals as they appear in life. I cordially recommend those who have not seen this collection to accept Mr. Carpenter's invitation, and accompany him this afternoon, when he will have an opportunity of showing this section as well as other sections of the Museum."

ALDERMAN CAMERON: "A most prolific idea for the future is thrown out by this paper. How are the main ideas in modern science to be presented in the best possible way? I would suggest to Mr. Carpenter that he should publish a memoir and show how it could be done practically."

MR. HOWARTH: "I rise chiefly to explain a circumstance that occurred a week or two ago. In a town in Lancashire they erected a fine institution, which they intend fitting up as a Science and Art Museum, and the gentleman who, in an honorary capacity, has hitherto looked after the Museum is offering to continue his services in the larger sphere of the new building—not quite the best form of curator in a large establishment. He proposes to arrange the whole Museum simply as a Geographical Collection. I wish Mr. Carpenter could have a little talk with him, and impress upon him the true value of geographical distribution."

THE PRESIDENT: "I think there is considerable analogy and close affinity between the two questions—that of the section described by Mr. Carpenter and the subject dealt with by Mr. Rudler. Some museums cannot attempt a systematic series and also a special series. I am sure Mr. Carpenter will adopt the suggestion of publishing a book on the subject. If a tempting offer should be

made to him, I think it would be very well if he combined with Mr. Rudler in producing a joint manual. The two subjects are closely connected—the first, what a museum can contain, and next, what it is best to throw its principal effort into."

MR. WILLIAM WHITE: "Perhaps it is due to the difficulty that is found owing to the want of space in museums, but I think the only objection that any one could raise is that the beautiful series that most of us have already seen is so crowded. I should like to see it extended very much farther, and more fully illustrated. But that is just the difficulty that we have been referring to, and the only way in which most museums will be able to extend in this direction will be by the very general use of maps. That is a method that can be applied most usefully, and it is one that has already been stated to be extremely attractive to the general public, and a means of their first taking an interest in the things that they see."

MR. PLATNAUER: "I just make one practical suggestion, and that is, that when Mr. Carpenter has got his cases finished to his satisfaction, he should take a photograph of them on a pretty large scale; and I think it would certainly be an advantage if we had reproductions of these photographs published in the annual report. We all know how inferior are diagrams to actual pictures. Of course this may be an expensive matter. Mr. Howarth has his finger on the financial pulse of the Association, and can tell us when we are on a sufficiently sound financial basis; then I think we ought to do it."

MR. CARPENTER: "I have only to thank those who have spoken for the way in which they have referred to my work. We might easily get photographs taken. With regard to the descriptive labels, we have a good many copies of them."

MUSEUMS ASSOCIATION.

REPORT OF PROCEEDINGS

WITH THE PAPERS READ AT THE

FIFTH ANNUAL GENERAL MEETING,

HELD IN DUBLIN, JUNE 26 to 29, 1894.

EDITED BY

E. HOWARTH, F.R.A.S., & H. M. PLATNAUER, B.Sc.

SHEFFIELD AND YORK:

PUBLISHED BY THE ASSOCIATION.

1895.

CONTENTS.